SYSTEMATIC REVIEW

Nasal Intermittent Positive Pressure Ventilation *versus* Nasal Continuous Positive Airway Pressure in Neonates: *A Systematic Review and Meta-analysis*

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Objective: To compare the efficacy and safety of Nasal intermittent positive pressure ventilation (NIPPV) and Nasal continuous positive airway pressure (nCPAP) in neonates.

Methods: Standard search strategy for the Cochrane Neonatal Review Group was performed. The participants were both preterm and term infants suffering from neonatal respiratory distress syndrome or experiencing apnea of prematurity.

Results: 14 eligible andomized controlled trials involving 1052 newborn infants were included. The study quality and evidence validity was defined as moderate. As compared with nCPAP, NIPPV significantly reduced the incidence of endotracheal ventilation (OR=0.44, 95%CI:0.31–0.63), increased the successful rate of extubation (OR=0.15, 95%CI:0.08–0.31), and had a better outcome indicated by decreased death and/or bronchopulmonary dysplasia (OR=0.57, 95%CI:0.37–0.88). Moreover, NIPPV decreased the number of apneic episodes of prematurity (WMD=-0.48, 95%CI:-0.58–0.37), and marginally decreased the incidence of bronchopulmonary dysplasia (OR=0.63, 95%CI:0.39–1.00). No side effects specifically associated with NIPPV were reported.

Conclusions: NIPPV could be used to reduce endotracheal ventilation, increase successful extubation, decrease the rate of apnea of prematurity, and have better outcome indicated by fewer death and/or bronchopulmonary dysplasia in preterm and term newborn infants.

Key words: Management, Mechanical ventilation, Neonate, Respiratory distress syndrome, Outcome.

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Nasal intermittent positive pressure ventilation (NIPPV) has been widely used in neonatal intensive care unit (NICU) [1]. As a mode of non-invasive ventilation, NIPPV is suggested to increase the beneficial effects of nasal continuous positive airway pressure (nCPAP) and, therefore, decrease the need for endotracheal intubation. Several explanations have been put forward for the mechanism of NIPPV [2-4]. Addition of increased flow delivery in the upper airway, increased tidal and minute volumes, increased functional residual capacity, recruitment of collapsed alveoli, improved stability of the chest wall, and less asynchrony of thoraco-abdominal movement have been shown with the application of NIPPV in newborn infants [5].

Some meta-analyses on the comparison of the effect of NIPPV with nCPAP in neonatal respiratory distress syndrome (NRDS) were published on Cochrane Database a few years ago [6-8]. However, only preterm infants were included in these. Recently, NIPPV has been further studied in randomized controlled trials. In addition to major outcome, more data on bronchopulmonary dysplasia (BPD), retinopathy of prematurity (ROP), intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL) have been investigated. More studies on the safety of NIPPV were also reported, which concerned the incidence of pneumothorax or air leak, abdominal distention, necrotizing enterocolitis, and patent ductus arteriosus (PDA). Hence, it is necessary to systematically evaluate the effectiveness of NIPPV compared with nCPAP in NRDS.

METHODS

Criteria for inclusion and exclusion: Studies were included in the systematic review if they were randomized or quasi-randomized. The participants were both preterm and term infants suffering from neonatal respiratory distress syndrome (NRDS) or experiencing apnea of prematurity. The interventions for comparison were NIPPV and nCPAP. Studies which did not report outcomes specified in this review were excluded.

NRDS has been suggested not only to be present in preterm infants but also in term infants [9]. Studies

involved both preterm and term infants were eligible if there were clinical evidences of NRDS. The diagnosis of NRDS was based on clinical manifestation and *X*-ray picture [10].

Outcome measures: During NIPPV *versus* nCPAP in the post-extubation period, the major outcome was respiratory failure leading to endotracheal intubation and mechanical ventilation. When NIPPV *versus* nCPAP were used as a primary respiratory support, the major outcome was the need of intubation. The secondary outcomes included the rate of apnea, the incidence of BPD, ROP, IVH, PVL, PDA, pneumothorax or air leak, abdominal distention, necrotizing enterocolitis, the total stay in the hospital, and the mortality. Final outcome was determined by the mortality and/or BPD. A good outcome was defined as the infant could be discharged without oxygen treatment, whereas a bad outcome was defined as death and/or BPD.

Search strategy and methods of the review: Standard search strategy for the Cochrane Neonatal Review Group was performed. Searches were made in PubMed, EMBASE, Ovid, Springer and China Knowledge Resource Integrated (CNKI) databases with the terms: newborn OR preterm AND respiratory distress syndrome AND nasal intermittent positive pressure ventilation AND nasal continuous positive airway pressure. The search time was from the beginning of the databases to March 2011. Grey literature and conference abstracts were not searched.

Two reviewers performed searches and assessed study quality independently. Study quality was assessed according to Cochrane Handbook for Systematic Reviews of Interventions Version 5.0.2, which included allocation concealment, sequence generation, blinding of participants, blinding of researchers, blinding of assessors, incomplete data address, free of selective reporting, and free of other bias [11]. If the article fulfilled all the mentioned criteria, it was classified as adequate and with the least possibility of bias. If the article could not fulfill more than one criterion, it was classified as highly deflective. Discussions were made by the reviewers group when there were different opinions about the evaluation for the quality of articles.

Data were extracted and analysed independently by the two reviewers, following the methods of the Cochrane Collaboration and using the statistical software of Review Manager 4.22, then compared, and the differences resolved.

Statistical analysis: A chi-square test was used to evaluate the statistical homogeneity. If $P \geq 0.10$, it was judged as statistically non-heterogeneous, and a fixed effect model selected. If $P < 0.10$, it was judged statistically heterogeneous, and a random effect model selected. Categorical data were analyzed using odds ratio (OR) with 95% confidence intervals (95% CI). Continuous data were analyzed using means and weighted mean difference (WMD) with 95% CI. A *P* value <0.05 was defined as significant.

RESULTS

On initial search 103 articles were identified, including 97 English papers and 6 papers in other languages with English abstracts (4 Chinese, 1 Spanish, 1 Polish). According to the inclusion criteria, 14 randomized controlled trials involving 1052 newborn infants were included (11 English, 3 Chinese) [12-25]. The selection course of the papers was shown as ***Fig* 1**. Among them, 5 trials investigated the effect of NIPPV *versus* nCPAP in the post-extubation period following ETT and mechanical ventilation [12-16] (***Web Table* I**). The other 9 trials studied the effect of NIPPV *versus* nCPAP as a primary respiratory support [17-25] (***Web Table* II**).

The basic data were compared to understand the clinical homogeneity of the included studies, which showed a comparable basic line. Five papers on NIPPV *versus* nCPAP as mode of extubation were clinically heterogeneous in gestational age, birth weight, regulation data of NIPPV or nCPAP, criteria for extubation, and criteria for re-intubation. Nine papers on NIPPV *versus* nCPAP as a primary respiratory support had a clinical homogeneity in the inclusive criteria, regulation data of NIPPV or nCPAP, and outcome measure, but there was a little clinically heterogeneity in gestational age and birth weight, because 2 studies involved both preterm and term infants, and 1 paper studied late-preterm infants. Most of the major patients were preterm infants with low or very low birth weight, and there were not enough term infants to be analysed in sub-group.

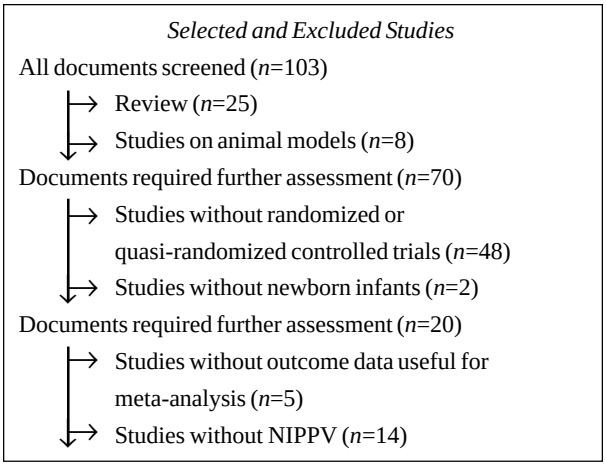

FIG.1 *The selection course of the papers.*

Methodological quality: The results of the assessment of methodological quality is shown in ***Web Fig.* 1.** Adequate concealment at randomization, complete follow-up, and free of selective reporting was identified in all 14 studies. Thirteen studies mentioned the sequence generation. Two studies stated no blinding of researchers.

Major outcome: Five papers [12-16] reported the rate of extubation failure of NIPPV *versus* nCPAP following ETT and mechanical ventilation. The studies were statistically homogeneous (P=0.64), and a fixed effect model was selected. Meta-analysis showed that the rate of extubation failure of NIPPV was significantly lower than that of nCPAP [OR=0.15 (95% CI: 0.08 0.31)]; P<0.001 (***Fig.* 2**).

Six papers [20-25] reported the failure rate of NIPPV *versus* nCPAP as a primary respiratory mode, which was indicated by whether or not requiring ETT and mechanical ventilation. The results were statistically homogeneous (P=0.58), and a fixed effect model was selected. Meta-analysis showed that the failure rate of not needing needing ETT and mechanical ventilation in NIPPV group was significantly lower than that in nCPAP group as a primary respiratory mode [OR=0.44 (95% CI: 0.31-0.63); P<0.0001) (***Fig.* 3**).

Secondary outcome: Five papers [20-23,25] reported the comparison of NIPPV and nCPAP on the final outcome as a primary respiratory mode, which was indicated by death

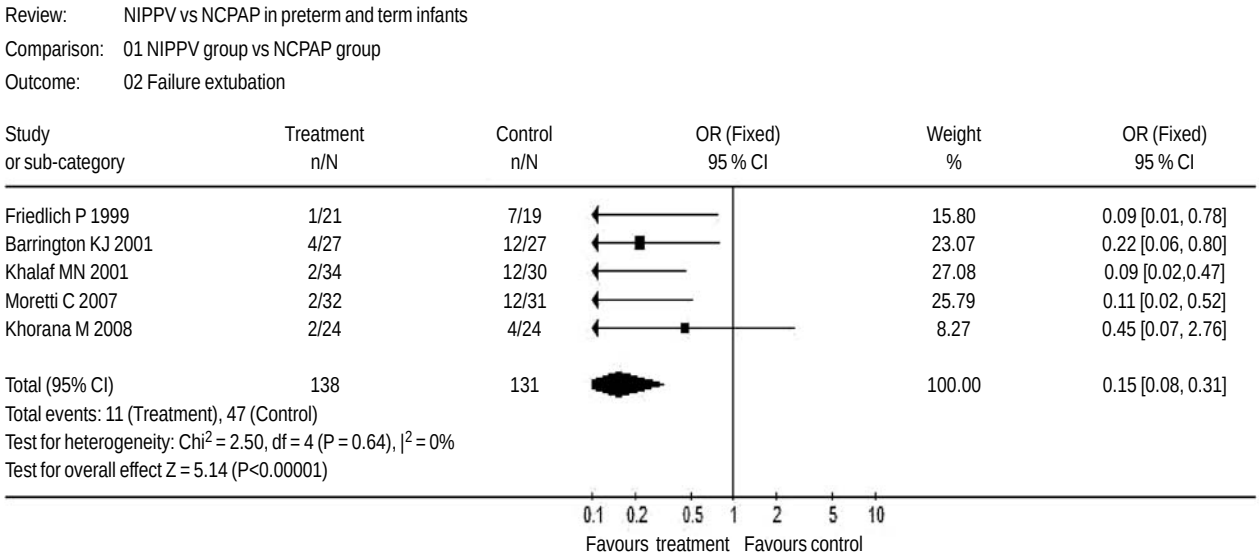

FIG.2 *The failure extubation rate of NIPPV versus nCPAP.*

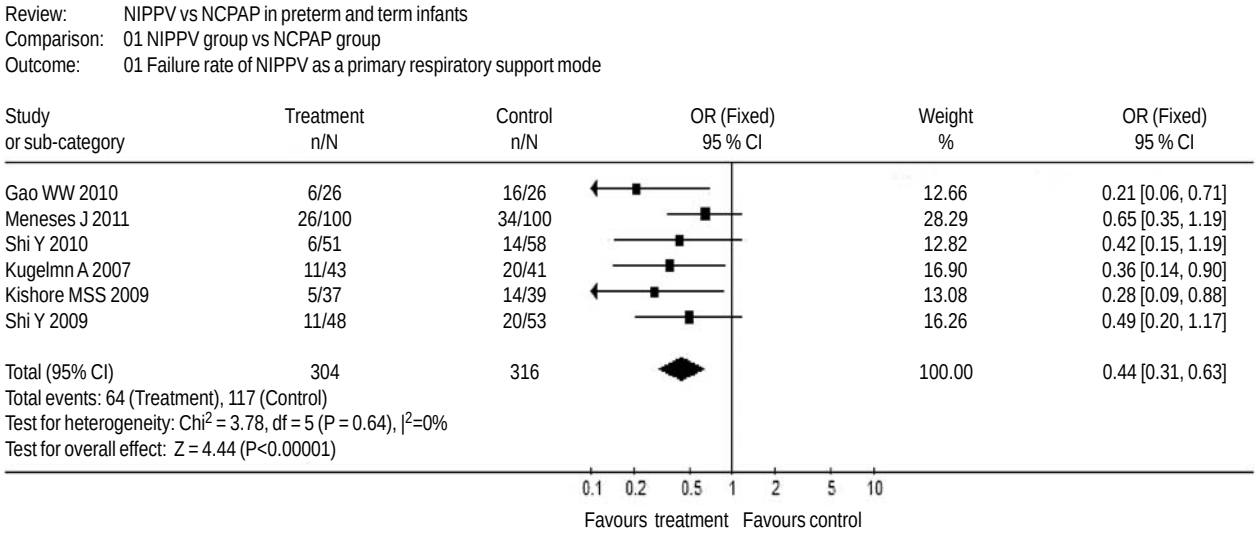

FIG.3 *The failure rate of NIPPV versus nCPAP as a primary respiratory mode.*

and/or BPD requiring respiratory supportive treatment at discharge. The results were statistically homogeneous (*P*=0.29), and a fixed effect model selected. Meta-analysis showed that the final outcome of NIPPV was significantly better than that of nCPAP as a primary respiratory mode [OR=0.57 (95% CI: 0.37-0.88); *P*=0.01] **(*Web Fig.* 2)**.

Three papers [17-19] reported the comparison of NIPPV *versus* nCPAP in the management of apnea of prematurity. The test for heterogeneity was non-significant (*P*=0.21), and a fixed effect model selected. Meta-analysis showed a statistically lower rate of apnea (episodes per hour) in the NIPPV group as compared with nCPAP group [WMD=-0.48 (95%CI:-0.58-0.37; *P*<0.001] (***Web Fig.* 3**).

Five papers [13,16,20-21,25] reported the comparison of duration of hospitalization between NIPPV and nCPAP group including the studies either as a primary respiratory mode or as a extubation mode. A random effect model was selected because of significant heterogeneity (*P*=0.06). Meta-analysis showed that there was no significant difference in duration of hospitalization between NIPPV and nCPAP group [WMD=-0.51 (95%CI:-5.62-4.61; *P*=0.85] (***Web Fig.* 4**).

***Table* I** showed the incidence of BPD, IVH or PVL, ROP, pneumothorax or air leak, abdominal distention, necrotizing enterocolitis, and PDA in the group of NIPPV *versus* nCPAP. Except for the incidence of BPD (*P*=0.05), there was no significant difference between the NIPPV and nCPAP groups respectively (*P*>0.05).

DISCUSSION

Respiratory distress syndrome in preterm infants is still a big challenge for neonatologists [26]. In recent year, increased morbidity of NRDS in late-preterm and term infants has been reported [27]. Although the mortality of NRDS has been significantly reduced the prolonged use of ETT and mechanical ventilation might predispose the neonates to the development of BPD. nCPAP has been widely used as a non-invasive respiratory supportive mode for NRDS [28]. However, nCPAP could not consistently improve ventilation and could not be effective in newborn infants with poor respiratory effort. In fact, as many as 55% preterm infants at the gestational age of 25-26 wk and 40% of 27-28 wk treated by nCPAP developed respiratory failure and needed ETT and mechanical ventilation within five days [29]. NIPPV has been suggested to have stronger respiratory supportive effect than nCPAP [30]. NIPPV has been confirmed to decrease the work of breathing in preterm infants with NRDS as compared with nCPAP [31].

As compared with the previously published meta-analyses [5-7,32] on the comparison of NIPPV and nCPAP, the present study also included the newly published RCT articles, involved both preterm and term infants, and assessed the effect and safety in the round. The present meta-analysis results showed that, as a primary respiratory supportive mode, NIPPV could significantly reduce the need for ETT and mechanical ventilation, decrease the apnea episodes of prematurity, and have a better clinical outcome as compared with nCPAP. NIPPV might be a valuable mode of primary respiratory support. Till now, only one RCT study investigated the comparison of NIPPV and mechanical ventilation in preterm infants after pulmonary surfactant administration [33], which suggested that the group treated by NIPPV had shorter duration of hospitalization, lower BPD and mortality than that treated by mechanical ventilation. A prospective observational study also suggested that NIPPV was a safe and effective primary mode of ventilation in premature infants [34].

The present meta-analysis results confirmed that NIPPV had a better effect than nCPAP in the post-extubation period. Moreover, NIPPV led to a marginally significant reduction in the incidence of BPD as

TABLE I META-ANALYSIS OF SECONDARY OUTCOMES BETWEEN NIPPV AND NCPAP GROUPS

Outcomes	*n/N*[1)]	*n/N*[2)]	*Heterogeneity*	*OR(95%CI)*	*P*
BPD [13-14,16, 20-21,25]	45/273	60/268	*P*=0.46	0.63 (0.39~1.00)	0.05
IVH or PVL[14,17,20-21,25]	36/219	46/216	*P*=0.76	0.70 (0.43~1.15)	0.16
ROP [14,16,25]	23/130	30/132	*P*=0.12	0.66 (0.35~1.25)	0.20
pneumothorax or air leak[12,14,16,21,25]	14/225	23/219	*P*=0.44	0.55 (0.27~1.10)	0.09
abdominal distention[15,19]	6/66	5/70	*P*=0.39	1.28 (0.37~4.44)	0.70
necrotizing enterocolitis[14-16,21,25]	12/227	19/224	*P*=0.71	0.61(0.29~1.28)	0.19
PDA[14,16,25]	50/166	51/161	*P*=0.67	0.92 (0.56~1.52)	0.76

1): total patients of NIPPV group; 2): total patients of nCPAP group; BPD: bronchopulmonary dysplasia; IVH: intraventricular hemorrhage; PVL: periventricular leukomalacia; ROP: retinopathy; PDA: patent ductus arteriosus

WHAT THIS STUDY ADDS?

- NIPPV could significantly reduce endotracheal ventilation, increase successful extubation, improve apnea of prematurity, decrease the incidence of BPD, and have better outcome as compared with nCPAP.

compared with nCPAP. A clinical retrospective study also suggested that NIPPV use in infants with birth weight of 500-750 g was associated with decreased BPD, BPD/death, and neurodevelopmental impairment when compared with those managed with nCPAP [35]. The present meta-analysis results showed that there were no significant differences in the incidence of IVH, PVL, ROP, PDA, pneumothorax or air leak, abdominal distention, necrotizing enterocolitis, and duration of hospitalization between the group of NIPPV and nCPAP. There were no other severe complications associated with NIPPV or nCPAP reported.

nCPAP has been confirmed to be easy, and simple to use treatment of NRDS. As compared with nCPAP, NIPPV might provide slight but important beneficial effects. NIPPV has been successfully established as an effective treatment for NRDS, but the mechanism of action of NIPPV needs further investigations. The research on different ventilator equipment (synchronized *versus* non-synchronized) or method of synchronization should be continued. Pressure variation during ventilator generated NIPPV might have some negative effect in preterm infants [36]. A randomized crossover trial of four nasal respiratory support systems on apnea of prematurity in very low birth weight infants suggested that a variable flow nCPAP device might be more effective than a conventional ventilator in NIPPV mode [37]. NIPPV has been provided by different study investigators using different ventilator equipment (synchronized *versus* non-synchronized) or method of synchronization. Similarly, comparative nCPAP has been provided using different types of pressure generators. There is another new mode of two-pressure level respiratory support biphasic positive airway pressure (BiPAP). The safety, i.e. long-term efficacy of these different non-invasive respiratory supports need further investigation [38].

Limitations of the present meta-analysis: The study quality and evidence validity was defined as moderate. Most of the studies involved small number of patients and therefore there was a wide confidence interval in the pooled results. It's difficult to compare the sub-group of different gestational age and birth-weight because of lack of data for term infants. The effects of NIPPV in late preterm and term neonates need further studies. The present study had insufficient data on important short term (IVH, PVL) and long term (neurological) outcomes.

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REFERENCES

1. DiBlarsi RM. Neonatal noninvasive ventilation techniques: do we really need to intubate? Respir Care. 2011;56:1273-97.
2. Bancalari E, Nelson C. Non-invasive ventilation of the preterm infant. Early Huma Develop. 2008;84:815-9.
3. Bhandari V. Nasal intermittent positive pressure ventilation in the newborn:review of literature and evidence-based guidelines. J Perinatol. 2010;30:505-12.
4. Davis PG, Morley CJ, Owen LS. Non-invasive respiratory support of preterm neonates with respiratory distress: continuous positive pressure and nasal intermittent positive ventilation. Semin Fetal Neonatal Med. 2009;14:14-20.
5. Lampland AL, Meyers PA, Worwa CT, Swanson EC, Mammel MC. Gas exchange and lung inflammation using nasal intermittent positive-pressure ventilation versus synchronized intermittent mandatory ventilation in piglets with saline lavage-induced lung injury: an observational study. Crit Care Med. 2008;36:183–7.
6. Davis PG, Lemyre B, de Paoli AG. Nasal intermittent positive pressure ventilation (NIPPV) versus nasal continuous positive airway pressure (NCPAP) for preterm neonates after extubation. Cochrane Database Syst Rev. 2001;3: CD003212.
7. Ho JJ, Subramaniam P, Henderson-Smart DJ, Davis PG. Continuous distending pressure for respiratory distress syndrome in preterm infants. Cochrane Database Syst Rev. 2002;2:CD002271.
8. Lemyre B, Davis PG, de Paoli AG. Nasal intermittent positive pressure ventilation (NIPPV) *versus* nasal continuous positive airway pressure (NCPAP) for apnea of prematurity. Cochrane Database Syst Rev. 2002;1: CD002272.
9. Ma XL, Xu XF, Chen C, Yan CY, Liu YM, Liu L, *et al*. Epidemiology of respiratory distress and the illness severity in late preterm or term infants: a prospective multi-center study. Chin Med J (Eng). 2010;123:2776-80.
10. Kero PO, Makinen EO. Comparison between clinical and radiological classification of infants with respiratory distress syndrome. Eur J Pediatr. 1979;130: 271-8.
11. Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions, Version 5.0.2.
12. Friedlich P, Lecart C, Posen R, Ramicone E, Chan L, Ramanathan R. A randomized trial of nasopharyngeal-synchronized intermittent mandatory ventilation versus nasopharyngeal continuous positive airway pressure in very low birth weight infants after extubation. J Perinatol.

1999;19:413-8.
13. Barrington KJ, Bull D, Finer NN. Randomized trial of nasal synchronized intermittent mandatory ventilation compared with continuous positive airway pressure after extubation of very low birth weight infants. Pediatrics. 2001;107:638-41.
14. Khalaf MN, Brodsky N, Hurley J, Bhandari V. A prospective randomized, controlled trial comparing synchronized nasal intermittent positive pressure ventilation versus nasal continuous positive airway pressure as modes of extubation. Pediatrics. 2001;108:13-7.
15. Khorana M, Paradeevisut H, Sangtawesin V, Kanjanapatanakul W, Chotigeat U, Ayutthaya JK. A randomized trial of non-synchronized Nasopharyngeal Intermittent Mandatory Ventilation (nsNIMV) *vs.* Nasal Continuous Positive Airway Pressure (NCPAP) in the prevention of extubation failure in pre-term < 1,500 grams. J Med Assoc Thai. 2008;91:S136-42.
16. Moretti C, Giannini L, Fassi C, Gizzi C, Papoff P, Colarizi P. Nasal flow-synchronized intermittent positive pressure ventilation to facilitate weaning in very low-birthweight infants: unmasked randomized controlled trial. Pediatr Int. 2008; 50:85-91.
17. Ryan CA, Finer NN, Peters KL. Nasal intermittent positive-pressure ventilation offers no advantages over nasal continuous positive airway pressure in apnea of prematurity. Am J Dis Child. 1989;143:1196-8.
18. Lin CH, Wang ST, Lin YJ, Yeh TF. Efficacy of nasal intermittent positive pressure ventilation in treating apnea of prematurity. Pediatr Pulmonol. 1998;26:349-53.
19. Bisceglia M, Belcastro A, Poerio V, Raimondi F, Mesuraca L, Crugliano C, *et al*. A comparison of nasal intermittent versus continuous positive pressure delivery for the treatment of moderate respiratory syndrome in preterm infants. Minerva Pediatr. 2007; 59:91-5.
20. Kugelman A, Feferkorn I, Riskin A, Chistyakov I, Kaufman B, Bader D. Nasal intermittent mandatory ventilation versus nasal continuous positive airway pressure for respiratory distress syndrome: a randomized, controlled, prospective study. J Pediatr. 2007;150:521-6.
21. Kishore MSS, Dutta S, Kumar P. Early nasal intermittent positive pressure ventilation *versus* continuous positive airway pressure for respiratory distress syndrome. Acta Paediatr. 2009;98:1412-5.
22. Shi Y, Tang SF, Shen J, Zhao JN, Hu ZX, Li HQ. Nasal intermittent positive pressure ventilation *versus* nasal continuous positive airway pressure for the treatment of neonatal respiratory failure : a prospective, randomized, controlled study. Chin J Evid based Pediatr. 2009;4:494-8.
23. Shi Y, Tang SF, Zhao JN, Hu ZX, Li TY. Efficiency of nasal intermittent positive pressure ventilation *vs* nasal continuous positive airway pressure on neonatal respiratory distress syndrome: a prospective, randomized, controlled study. Acta Acad Med Mil Tertiae. 2010;32:1991-4.
24. Gao WW, Tan SZ, Chen YB, Zhang Y, Wang Y. [Randomized trail of nasal synchronized intermittent mandatory ventilation compared with nasal continuous positive airway pressure in preterm infants with respiratory distress syndrome]. Chin J Contemp Pediatr. 2010;12:524-6.
25. Meneses J, Bhandari V, Alves JG, Herrmann D. Noninvasive ventilation for respiratory distress syndrome: A randomized controlled trial. Pediatrics. 2011;127: 300-7.
26. Mathews TJ, MacDorman MF. Infant mortality statistics from 2005 period linked birth/infant death data set. Natl Vital Stat Rep. 2008;57:1-32.
27. Hansen AK, Wisborg K, Uldbjerg N, Henriksen TB. Elective caesarean section and respiratory morbidity in the term and near-term neonate. Acta Obstet Gynecol Scand. 2007;86:389-94.
28. Dani C, Corsini I, Bertini G, Fontanelli G, Pratesi S, Rubaltelli FF. The INSURE method in preterm infants of less than 30 weeks' gestation. J Matern Fetal Neonatal Med. 2010;23:1024-9.
29. Kirchner L, Weninger M, Unterasinger L, Birnbacher R, Hayde M, Krepler R, *et al*. Is the use of early nasal CPAP associated with lower rates of chronic lung disease and retinopathy of prematurity? Nine years of experience with the Vermont Oxford Neonatal Network. J Perinat Med. 2005;33:60-6.
30. Ramanathan R. Nasal respiratory support through the nares: its time has come. J Perinatol. 2010;30:S67-72.
31. Aghai ZH, Saslow JG, Nakhla T, Milcarek B, Hart J, Lawrysh-Plunkett R, *et al*. Synchronized nasal intermittent positive pressure ventilation (SNIPPV) decreases work of breathing (WOB) in premature infants with respiratory distress syndrome (RDS) compared to nasal continuous positive airway pressure (NCPAP). Pediatr Pulmonol. 2006;41:875-81.
32. De Paoli AG, Davis PG, Faber B, Morley CJ. Devices and pressure sources for administration of nasal continuous positive airway pressure (NCPAP) in preterm neonates. Cochrane Database Syst Rev. 2008;1:CD002977.
33. Bhandari V, Gavino RG, Nedrelow JH, Pallela P, Salvador A, Ehrenkranz RA, *et al*. A randomized controlled trial of synchronized nasal intermittent positive pressure ventilation in RDS. J Perinatol. 2007;27:697-703.
34. Santin R, Brodsky N, Bhandari V. A prospective observational pilot study of synchronized nasal intermittent positive pressure ventilation (SNIPPV) as a primary mode of ventilation in infants > or = 28 weeks with respiratory distress syndrome (RDS). J Perinatol. 2004;24:487-93.
35. Bhandari V, Finer NN, Ehrenkranz RA, Saha S, Das A, Walsh MC, *et al*. Synchronized nasal intermittent positive-pressure ventilation and neonatal outcomes. Pediatrics. 2009;124:517-26.
36. Owen LS, Morley, CJ, Davis PG. Pressure variation during ventilator generated nasal intermittent positive pressure ventilation in preterm infants. Arch Dis Fetal Neonatal Ed. 2010;95:F359-64.
37. Pantalitschka T, Sievers J, Urschitz MS, Herberts T, Reher C, Poets CF. Randomized crossover trial of four nasal respiratory support systems on apnoea of prematurity in very low birth weight infants. Arch Dis Child Fetal Neonatal Ed. 2009; 94:F245-8.
38. Kieran EA, Walsh H, O'Donnell CPF. Survey of nasal continuous positive airways pressure (NCPAP) and nasal intermittent positive pressure ventilation (NIPPV) use in Irish newborn nurseries. Arch Dis Child Fetal Neonatal Ed. 2011;96:F156.